PATENT COOPERATION TREATY

From th INTERNATIONAL SEARCHING AUTHORITY

To:

Patent Attorney KINOSHITA, Jitsuzo
3rd Floor, Ogikubo TM Bldg.,
26-13, Ogikubo, 5-chome
Suginami-ku, TOKYO 167
JAPAN

PCT

COMMUNICATION IN CASES FOR WHICH
NO OTHER FORM IS APPLICABLE

Applicant's or agent's file reference EPS(pct)011	Date of mailing *(day/month/year)* 09/08/2001
International application No. PCT/JP 01/05898	**REPLY DUE** See paragraph 1 below
Applicant SEIKO EPSON CORPORATION et al.	International filing date *(day/month/year)* 06/07/2001

1. [ ] REPLY DUE within _____ ~~months~~/days from the above date of mailing

   [X] NO REPLY DUE

2. COMMUNICATION:

The applicant is informed that **establishment of the international search report (ISR) may be delayed due to th search backlog in the technical field concerned.** Irrespective of when the applicant receives the ISR howev r, h must file a demand for international preliminary examination before the expiration of 19 months from the priority dat in order to obtain postponement of the time limit for entry into the national phase from 20 (EPO:21) to 30 (EPO:31) months from the priority date (Article 39(1)(a)PCT); **the 19-month time limit is not extendable even if the ISR is delayed.**

In these circumstances, the EPO acting as IPEA will accept, without any late payment fee under Rule 58*bis* PCT, the handling fee and the preliminary examination fee due in respect of the demand relating to the present application, even if they are not paid within the time limit prescribed in Rules 57.3 and 58.1(b)PCT, provided that they are **paid within one month from the date of transmittal of the ISR**; i.e., the EPO will only apply Rule 58*bis* PCT after expiry of this one-month period.
In all cases where the EPO has sent an invitation to pay and the applicant has not paid in full the amount due, the demand shall be considered as if it had not been submitted (Rule 58*bis*.1 (b)-(d) PCT). A loss of rights may well be the consequence in designated states where the time limit for entry into the national phase under Article 22 PCT has already expired (see also Article 37(4) PCT).

Note that if the competent IPEA chosen by the applicant is not the EPO and if the fees mentioned above are not paid within the time limit prescribed in Rules 57.3 and 58.1(b)PCT, the competent IPEA is entitled to apply Rule 58*bis* PCT immediately thereafter.

We apologise for any inconvenience caused.

Name and mailing address of the International Searching Authority European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer ISA/EP

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
EPS(pct)011		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/JP 01/ 05898	06/07/2001	11/07/2000
Applicant		
SEIKO EPSON CORPORATION et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 7 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box i).

3. [X] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 3

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
Patent Attorney KINOSHITA, Jitsuzo
3rd Floor, Ogikubo TM Bldg.,
26-13, Ogikubo, 5-chome
Suginami-ku, TOKYO 167
JAPAN

NOTIFICATION OF RECEIPT OF SEARCH COPY

(PCT Rule 25.1)

Date of mailing *(day/month/year)*	09/08/2001
Applicant's or agent's file reference	IMPORTANT NOTIFICATION
EPS(pct)011	

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/JP 01/05898	06/07/2001	11/07/2000

Applicant

SEIKO EPSON CORPORATION et al.

1. **Where the International Searching Authority and the Receiving Office are not the same office:**

The applicant is hereby notified that the search copy of the international application was received by this International Searching Authority on the date indicated below.

Where the International Searching Authority and the Receiving Office are the same office:

The applicant is hereby notified that the search copy of the international application was received on the date indicated below.

19/07/2001 *(date of receipt).*

2. ☐ The search copy was accompanied by a nucleotide and/or amino acid sequence listing in computer readable form.

3. **Time limit for establishment of International Search Report**

The applicant is informed that the time limit for establishing the International Search Report is 3 months from the date of receipt indicated above or 9 months from the priority date, whichever time limit expires later

4. A copy of this notification has been sent to the International Bureau and, where the first sentence of paragraph 1 applies, to the Receiving Office.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	ISA/EP

INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP 01/05898

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16F1/02 C21D9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16F C21D C23C G04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
PAJ, EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 24 23 459 A (BAUER KG RINGFAB CHRISTIAN) 27 November 1975 (1975-11-27) page 2, paragraph 4	1,2,5,6, 12,13,15
X	PATENT ABSTRACTS OF JAPAN vol. 018, no. 444 (M-1658), 18 August 1994 (1994-08-18) & JP 06 137353 A (NHK SPRING CO LTD), 17 May 1994 (1994-05-17) abstract	1-8
Y		14
Y	US 5 835 456 A (FARINE PIERRE-ANDRE ET AL) 10 November 1998 (1998-11-10) column 4, line 25-41; figures	14
A		15

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 May 2002	05. 06. 02
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Pöll, A

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 024 346 A (KANEYASU MITSUTOSHI ET AL) 15 February 2000 (2000-02-15) figures	1,9-11
X	PATENT ABSTRACTS OF JAPAN vol. 013, no. 042 (C-564), 30 January 1989 (1989-01-30) & JP 63 241155 A (HIGH FREQUENCY HEATTREAT CO LTD), 6 October 1988 (1988-10-06) abstract	1,9-11
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 248 (C-0843), 25 June 1991 (1991-06-25) & JP 03 079790 A (SUMITOMO ELECTRIC IND LTD), 4 April 1991 (1991-04-04) abstract	1,3,6
A	US 5 380 407 A (YAMAOKA YUKIO ET AL) 10 January 1995 (1995-01-10) column 2, line 44 -column 3, line 8	1
A	US 5 226 979 A (THOMA PAUL E) 13 July 1993 (1993-07-13) figures	1
A	DE 199 29 184 A (MAGUIRE PAUL DAMIAN ;ANDERSON JOHN MCCUNE (IE); MCLAUGHLIN JAMES A) 30 December 1999 (1999-12-30) page 1, line 15-20 page 1, line 44-46	7,8
A	FR 1 091 672 A (ANTELME JACQUES) 14 April 1955 (1955-04-14) the whole document	1
A	US 3 937 001 A (BERNEY JEAN-CLAUDE) 10 February 1976 (1976-02-10) column 1, line 67 -column 2, line 9 column 3, line 34-43; figures	14,15
A	US 5 615 178 A (TAKAKURA AKIRA ET AL) 25 March 1997 (1997-03-25) column 8, line 18-27; figures	14,15
A	EP 0 990 961 A (SEIKO EPSON CORP) 5 April 2000 (2000-04-05) column 10, line 1-7; figures	14,15
A	US 5 668 414 A (HIROSHI YABE ET AL) 16 September 1997 (1997-09-16) figures 1,2	14,15

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International Application No
PCT/JP 01/05898

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 942 341 A (SEIKO EPSON CORP) 15 September 1999 (1999-09-15) figures	14,15
A	EP 0 684 216 A (ACROSS CO) 29 November 1995 (1995-11-29) page 3, line 5-10 page 4, column 21-24 page 7, line 3-20; figures	8-11
A	US 5 549 370 A (FOLSOM MARK F) 27 August 1996 (1996-08-27) column 9, line 14-47; figures	1,8-11
A	EP 0 551 566 A (SHINKO WIRE CO LTD) 21 July 1993 (1993-07-21) abstract; claim 9	1,9-11
A	GB 784 661 A (STRAUMANN INST AG) 16 October 1957 (1957-10-16) page 1, line 69-85	8-11
A	US 4 622 081 A (STICKELS CHARLES A ET AL) 11 November 1986 (1986-11-11) column 8, line 7-26	8-11
A	DATABASE WPI Section Ch, Week 198242 Derwent Publications Ltd., London, GB; Class M24, AN 1982-88879E XP002198512 & JP 57 145938 A (SUMITOMO ELECTRIC IND CO), 9 September 1982 (1982-09-09) abstract	8-11
A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 301 (C-521), 16 August 1988 (1988-08-16) & JP 63 072832 A (SHINKO KOSEN KOGYO KK;OTHERS: 01), 2 April 1988 (1988-04-02) abstract	8-11
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 265 (M-1608), 20 May 1994 (1994-05-20) & JP 06 042319 A (CITIZEN WATCH CO LTD), 15 February 1994 (1994-02-15) abstract	8-11
A	PATENT ABSTRACTS OF JAPAN vol. 009, no. 074 (C-273), 3 April 1985 (1985-04-03) & JP 59 205487 A (CHIYUUOU HATSUJIYOU KK), 21 November 1984 (1984-11-21) abstract	8-11

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/JP 01/05898

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 492 (C-1107), 7 September 1993 (1993-09-07) & JP 05 125558 A (NIPPON STEEL CORP), 21 May 1993 (1993-05-21) abstract -----	9

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/JP 01/05898

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 2423459 A	27-11-1975	DE 2423459 A1	27-11-1975
JP 06137353 A	17-05-1994	NONE	
US 5835456 A	10-11-1998	CH 690523 A5	29-09-2000
		JP 10177079 A	30-06-1998
		SG 67449 A1	21-09-1999
US 6024346 A	15-02-2000	JP 9112614 A	02-05-1997
JP 63241155 A	06-10-1988	JP 1884484 C	10-11-1994
		JP 6002933 B	12-01-1994
JP 03079790 A	04-04-1991	NONE	
US 5380407 A	10-01-1995	JP 2521387 B2	07-08-1996
		JP 5171493 A	09-07-1993
		DE 69220026 D1	03-07-1997
		DE 69220026 T2	16-10-1997
		DE 551566 T1	25-11-1993
		EP 0551566 A1	21-07-1993
		ES 2042455 T1	16-12-1993
US 5226979 A	13-07-1993	NONE	
DE 19929184 A	30-12-1999	DE 19929184 A1	30-12-1999
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		JP 2000064047 A	29-02-2000
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FR 1091672 A	14-04-1955	NONE	
US 3937001 A	10-02-1976	CH 597636 B5	14-04-1978
		CH 1691872 A	31-05-1977
		DE 2357244 A1	22-05-1974
		FR 2207303 A1	14-06-1974
		GB 1425908 A	25-02-1976
		IT 1001847 B	30-04-1976
		JP 50006373 A	23-01-1975
US 5615178 A	25-03-1997	JP 3174245 B2	11-06-2001
		JP 8101284 A	16-04-1996
		DE 69524497 D1	24-01-2002
		EP 0695978 A1	07-02-1996
		EP 0982638 A1	01-03-2000
		JP 2000329863 A	30-11-2000
EP 0990961 A	05-04-2000	JP 2000175391 A	23-06-2000
		EP 0990961 A1	05-04-2000
		US 6208055 B1	27-03-2001
US 5668414 A	16-09-1997	JP 3058813 B2	04-07-2000
		JP 8075874 A	22-03-1996
EP 0942341 A	15-09-1999	EP 0942341 A1	15-09-1999
		US 6041021 A	21-03-2000
		EP 0942340 A1	15-09-1999
		WO 9917171 A1	08-04-1999

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/JP 01/05898

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0942341 A		WO 9917172 A1	08-04-1999
		US 6252828 B1	26-06-2001
EP 0684216 A	29-11-1995	JP 3045889 B2	29-05-2000
		JP 6264947 A	20-09-1994
		US 5503783 A	02-04-1996
		EP 0684216 A1	29-11-1995
		DE 69422020 D1	13-01-2000
		DE 69422020 T2	29-06-2000
		US 5678809 A	21-10-1997
US 5549370 A	27-08-1996	AU 4145796 A	31-05-1996
		WO 9614519 A1	17-05-1996
		US 5603490 A	18-02-1997
EP 0551566 A	21-07-1993	JP 2521387 B2	07-08-1996
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		DE 69220026 D1	03-07-1997
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		US 5380407 A	10-01-1995
GB 784661 A	16-10-1957	NONE	
US 4622081 A	11-11-1986	CA 1271649 A1	17-07-1990
JP 57145938 A	09-09-1982	NONE	
JP 63072832 A	02-04-1988	JP 1907777 C	24-02-1995
		JP 5014771 B	25-02-1993
JP 06042319 A	15-02-1994	JP 2992134 B2	20-12-1999
JP 59205487 A	21-11-1984	JP 1557597 C	16-05-1990
		JP 63058210 B	15-11-1988
JP 05125558 A	21-05-1993	JP 2952840 B2	27-09-1999

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP 01/05898

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-8,12,13,15

A spring, wherein a plurality of layers of the film are provided. The problem solved by this feature can be said to be provide a plurality of different characteristics such as bonding strength by one film and anti-corrosion properties and slide properties by the remaining film (see page 5, line 11- page 6, line 4).

2. Claims: 9-11

A spring, wherein the film is a diffusion layer formed by diffusing a diffusion substance strongly bonded with a certain composition. The problem solved by this feature can be said to be to find a way of improving the diffusion process.

3. Claim : 14

An electronic timepiece comprising a power generator, gear train, indicator and rotation controller. The problem solved by these features can be said to be to provide an improved electronic timepiece.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

KINOSHITA, Jitsuzo
3rd. floor, Ogikubo TM building
26-13, Ogikubo 5-chome
Suginami-ku, Tokyo 167-0051
JAPON

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
07 August 2001 (07.08.01)	
Applicant's or agent's file reference	**International application No.**
EPS(pct)011	PCT/JP01/05898

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

SEIKO EPSON CORPORATION (for all designated States except US)
HARA, Tatsuo (for US)

International filing date	:	06 July 2001 (06.07.01)
Priority date(s) claimed	:	11 July 2000 (11.07.00)
Date of receipt of the record copy by the International Bureau	:	20 July 2001 (20.07.01)
List of designated Offices	:	

EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE,TR
National :CN,JP,US

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [X] confirmation of precautionary designations
- [X] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

Susumu Kubo

Telephone No. (41-22) 338.83.38

International application No.
PCT/JP01/05898

INFORMATION ON TIME LIMITS FOR ENTERING THE NATIONAL PHASE

The applicant is reminded that the "national phase" must be entered before each of the designated Offices indicated in the Notification of Receipt of Record Copy (Form PCT/IB/301) by paying national fees and furnishing translations, as prescribed by the applicable national laws.

The time limit for performing these procedural acts is **20 MONTHS** from the priority date or, for those designated States which the applicant elects in a demand for international preliminary examination or in a later election, **30 MONTHS** from the priority date, provided that the election is made before the expiration of 19 months from the priority date. Some designated (or elected) Offices have fixed time limits which expire even later than 20 or 30 months from the priority date. In other Offices an extension of time or grace period, in some cases upon payment of an additional fee, is available.

In addition to these procedural acts, the applicant may also have to comply with other special requirements applicable in certain Offices. **It is the applicant's responsibility** to ensure that the necessary steps to enter the national phase are taken in a timely fashion. Most designated Offices do not issue reminders to applicants in connection with the entry into the national phase.

For detailed information about the procedural acts to be performed to enter the national phase before each designated Office, the applicable time limits and possible extensions of time or grace periods, and any other requirements, see the relevant Chapters of Volume II of the PCT Applicant's Guide. Information about the requirements for filing a demand for international preliminary examination is set out in Chapter IX of Volume I of the PCT Applicant's Guide.

GR and ES became bound by PCT Chapter II on 7 September 1996 and 6 September 1997, respectively, and may, therefore, be elected in a demand or a later election filed on or after 7 September 1996 and 6 September 1997, respectively, regardless of the filing date of the international application. (See second paragraph above.)

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

CONFIRMATION OF PRECAUTIONARY DESIGNATIONS

This notification lists only specific designations made under Rule 4.9(a) in the request. It is important to check that these designations are correct. Errors in designations can be corrected where precautionary designations have been made under Rule 4.9(b). The applicant is hereby reminded that any precautionary designations may be confirmed according to Rule 4.9(c) before the expiration of 15 months from the priority date. If it is not confirmed, it will automatically be regarded as withdrawn by the applicant. There will be no reminder and no invitation. Confirmation of a designation consists of the filing of a notice specifying the designated State concerned (with an indication of the kind of protection or treatment desired) and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.

REQUIREMENTS REGARDING PRIORITY DOCUMENTS

For applicants who have not yet complied with the requirements regarding priority documents, the following is recalled.

Where the priority of an earlier national, regional or international application is claimed, the applicant must submit a copy of the said earlier application, certified by the authority with which it was filed ("the priority document") to the receiving Office (which will transmit it to the International Bureau) or directly to the International Bureau, before the expiration of 16 months from the priority date, provided that any such priority document may still be submitted to the International Bureau before that date of international publication of the international application, in which case that document will be considered to have been received by the International Bureau on the last day of the 16-month time limit (Rule 17.1(a)).

Where the priority document is issued by the receiving Office, the applicant may, instead of submitting the priority document, request the receiving Office to prepare and transmit the priority document to the International Bureau. Such request must be made before the expiration of the 16-month time limit and may be subjected by the receiving Office to the payment of a fee (Rule 17.1(b)).

If the priority document concerned is not submitted to the International Bureau or if the request to the receiving Office to prepare and transmit the priority document has not been made (and the corresponding fee, if any, paid) within the applicable time limit indicated under the preceding paragraphs, any designated State may disregard the priority claim, provided that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity to furnish the priority document within a time limit which is reasonable under the circumstances.

Where several priorities are claimed, the priority date to be considered for the purposes of computing the 16-month time limit is the filing date of the earliest application whose priority is claimed.

PCT REQUEST

EPS(pct)011

Original (for SUBMISSION) - printed on 06.07.2001 11:18:05 AM

0	For receiving Office use only	
0-1	International Application No.	
0-2	International Filing Date	
0-3	Name of receiving Office and "PCT International Application"	
0-4	Form - PCT/RO/101 PCT Request	
0-4-1	Prepared using	PCT-EASY Version 2.92 (updated 01.03.2001)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	Japan Patent Office (RO/JP)
0-7	Applicant's or agent's file reference	EPS(pct)011
I	Title of invention	SPRING, DRIVE MECHANISM, DEVICE AND TIMEPIECE USING THE SPRING
II	Applicant	
II-1	This person is:	applicant only
II-2	Applicant for	all designated States except US
II-4	Name	SEIKO EPSON CORPORATION
II-5	Address:	4-1, Nishishinjuku 2-chome Shinjuku-ku, Tokyo 163-0811 Japan
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VIII-1	Declaration as to the identity of the inventor	-	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	-	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	-	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-	
IX	Check list	number of sheets	electronic file(s) attached
IX-1	Request (including declaration sheets)	4	-
IX-2	Description	29	-
IX-3	Claims	3	-
IX-4	Abstract	1	EZABST00.TXT
IX-5	Drawings	8	-
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IX-8	Fee calculation sheet	✓	-
IX-9	Original separate power of attorney	✓	-
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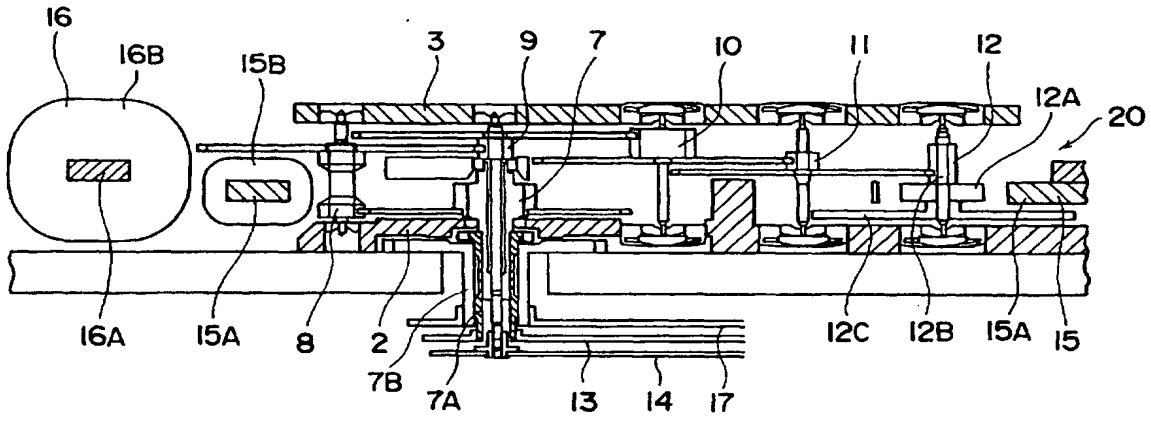
(54) Title: SPRING, DRIVE MECHANISM, DEVICE AND TIMEPIECE USING THE SPRING



(57) Abstract: A barrel gear 1 as a driving mechanism of an electronic control mechanical timepiece has a mainspring 1A having a surface of elastic material coated with a film made of DLC thin film. The mainspring 1A has a superior anti-corrosion property and reduced slide resistance while sufficiently securing both of toughness and rigidity on account of the film, so that proportional limit thereof can be increased to increase energy accumulated in the mainspring 1A.

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DESCRIPTION

SPRING, DRIVING MECHANISM, DEVICE AND TIMEPIECE USING THE SPRING

Technical Field

The present invention relates to a spring used as a machine element, a driving mechanism, a device and a timepiece using the spring.

Background Art

Conventionally, various springs with elastic modulus in accordance with desired usage have been manufactured by processing a material such as steel and stainless steel having elasticity.

For instance, a coil spring used for driving an intake valve and an exhaust valve of a gasoline engine, a plate spring used for shock absorber provided around wheels of a vehicle and a mainspring used as a power source of toys and timepieces have been known.

Since long drive time and great durability are not required for the mainspring for driving toys, steel-made or stainless-steel-made springs are used.

On the other hand, since long driving time and great durability are required for the springs for driving timepieces such as wristwatch, the springs are made by alloy containing chromium, cobalt, nickel etc. thereby obtaining high-performance spring having excellent allowable stress and fatigue strength.

The springs formed by alloys containing cobalt, nickel etc. are not

easy to be corroded by chemicals such as acid and has sufficient corrosion resistance.

Further, when the spring is wound to accumulate sufficient mechanical energy in the spring and the spring is unwound thereafter to extract mechanical energy accumulated in the spring, slide resistance is generated on account of contact between the spring and a case for accommodating the spring such as a barrel and a contact between the sides of the wound spring, thus losing the mechanical energy. Accordingly, the slide resistance of the spring is reduced by a lubricant containing molybdenum disulfide or surface treatment such as Teflon finish.

The energy amount accumulated in the spring such as helical spring is smaller as compared to batteries.

For instance, the density of the energy accumulated in the helical spring of a wristwatch is approximately one thousandth of a primary battery and one tenth of a secondary battery, so that only approximately two days of driving time can be obtained by driving with the spring. On the other hand, more than two years of driving time is possible by driving with the primary battery.

Incidentally, when resistance to corrosion is lost in increasing the energy amount accumulated in the spring such as helical spring, the spring may not be used for long term, thus causing problem for durability.

Further, since the slide resistance is increased in accordance with increase in accumulated energy amount, the mechanical energy obtainable from the spring decreases, so that practically usable energy amount can be insufficient even when the accumulated energy amount increases.

An object of the present invention is to provide a spring capable of increasing accumulated energy amount, a driving mechanism, a device and a

timepiece using the spring.

Another object of the present invention is to provide a spring having superior resistance to corrosion, a driving mechanism, a device and a timepiece using the spring.

Further object of the present invention is to provide a spring capable of reducing slide resistance, a driving mechanism, a device and a timepiece using the spring.

Disclosure of the Invention

A first aspect of the present invention is a spring manufactured by processing an elastic material, at least a part of the surface of the material formed with a film having composition and mechanical characteristics different from the material.

The elastic material refers not only so-called elastic member having superior elasticity such as steel and stainless steel, but also relatively soft material such as synthetic resin having moderate elasticity.

The film includes a thin film of other substance adhered on the surface of the material, an oxidation film formed by oxidizing the surface of a metal material, and a diffusion layer having other substance diffused from the surface of the material to the inside.

According to the first aspect of the invention, since the spring is formed of a material having mutually different mechanical characteristics, superior anti-corrosion property can be applied on the spring, slide resistance thereof can be reduced and energy accumulative therein can be increased by utilizing the superior mechanical characteristics inherent in the material and the film.

Specifically, the energy U capable of accumulating in the spring can

be represented as the following formula:

$$U = (V/6) * (\sigma^2/E)$$

In the formula, V represents a volume of a spring, σ represents a proportional limit of a spring and E represents Young's modulus.

According to the formula, since the energy U capable of being accumulated in the spring is inversely proportional to the Young's modulus and is proportional to the square of the proportional limit, when the predetermined Young's modulus is obtained, the proportional limit of the spring may be increased.

Accordingly, by using a highly elastic composition on either one of the material or the film and using a composition of great toughness to the other one of the material and the film, the Young's modulus can be secured while increasing the proportional limit, thereby increasing the accumulative energy amount.

Especially, when the rigid film is formed on the material, both of the Young's modulus and the proportional limit can be increased and the energy U accumulated in the spring is proportional to the square of the proportional limit, so that the accumulative energy can be securely increased when the Young's modules is increased.

When the film is of a composition having superior anti-corrosion property, superior anti-corrosion properties can be given to the spring irrespective of chemical characteristics of the material.

When a composition having superior self-lubricity or a composition having small slide resistance is used for the film, the slide resistance of the spring can be reduced without adding lubricant or surface treatment.

In the above spring, the film may preferably be harder than the material.

When the film is harder than the material, even when the material is relatively soft, sufficiently great Young's modulus can be secured by the film and the proportional limit of the spring can be increased, so that sufficient toughness can be secured by the composition of the material, thereby easily increasing the accumulative energy amount without substantially increasing the volume of the spring.

A plurality of layers of the film may be provided to the spring instead of single film. For instance, a plurality of films having different composition may be laminated, or alternatively, a plurality of films having prominently different content ratio of the composition may be laminated.

According to the above arrangement, even when all of the bonding strength to the material, anti-corrosion property and the slide resistance of the spring cannot be improved by a single film, by providing a plurality type of films having different characteristics, the bonding strength can be improved by one film, and the anti-corrosion properties and slide properties can be improved by the remaining film, thus achieving high-performance spring.

For instance, a first composition having great rigidity and small bonding strength to the material and a second composition which strongly adheres both to a first film and the material may be prepared, and a second film composed of the second composition may be directly formed on the material and a first film composed of the first composition may be formed on the second film, thereby obtaining the first film having great bonding strength.

Alternatively, a first composition having great rigidity and inferior anti-corrosion properties and self-lubricity and a second composition superior both in the anti-corrosion properties and self-lubricity may be

prepared, and a first film composed of the first composition may be formed directly on the material and the second film composed of the second composition may be formed on the first film, thereby obtaining a spring superior both in the anti-corrosion property and self-lubricity.

In the above-described spring, the material may preferably be processed in a band-shape and wound in helical shape so that the spring becomes a mainspring.

When the spring is the mainspring, in addition to increase in the accumulative energy by coating the film onto the material, since the shape of the mainspring is suitable for mechanically accumulating the energy, more energy accumulation is possible than the other form of springs of the same size, thereby increasing energy density.

The material may preferably has the film formed on a surface to which a compressive force is applied when the material is elastically deformed.

Accordingly, even when a composition of the film has great rigidity and durability against compressive force but is weak against tension, or when a film having small bonding strength to the material is formed, since the film is formed to a portion where the compressive force is applied, the film is not peeled off from the material even when the spring is deformed, thereby preventing damage of the spring.

The film may be a thin film of a substance harder than the material coated on the surface of the material.

There are various types of the compositions capable of being coated as the film which is highly rigid and is strong against the compression force. Such material can be easily obtained and has small anti-corrosion properties and slide resistance, so that accumulative energy can be increased and a

spring having superior anti-corrosion properties and small slide resistance can be obtained by coating the film of the composition.

For instance, when the film mainly made of carbon is coated on the material, hardness similar to diamond can be obtained, energy capable of being accumulated in the spring can be increased, superior anti-corrosion properties can be given to the spring and the slide resistance of the spring can be substantially reduced.

The material may be formed of a non-metal.

According to the above-described first aspect of the present invention, even when the elasticity of the material is not sufficient, in other words, even when sufficient Young's modulus cannot be obtained by the material, sufficient elasticity can be secured by the film, so that the material may be formed by non-metal composition, such as synthetic resin.

Further, composition having superior toughness such as synthetic resin reinforced by aramid fiber can be used as the composition of the material, so that toughness can be increased, thereby also increasing energy accumulation.

The film may preferably be formed on the material by a physical vapor evaporation of which film-forming temperature is around a room temperature.

The physical vapor evaporation may be high-vacuum arc discharge vapor evaporation having film-forming temperature of 0 to 100°C. According to the high-vacuum arc discharge vapor evaporation, the film-forming temperature may be within 20 to 60°C in forming the material of the carbon film on the material.

Accordingly, the synthetic resin material which is easily influenced by heat can be used as the material, thereby widening selecting range of the

composition of the material.

When the material is formed by a material capable of precision processing such as synthetic resin, high-performance spring can be efficiently manufactured with the use of injection molding etc.

On the other hand, the film is not restricted to a thin film coated on the surface of the above-described material, but may be a diffusion layer formed harder than the material by diffusing a diffusion substance strongly bonded with the substance constituting the material from the surface of the material to the inside thereof.

When the diffusion layer is used as the film, since the spring is formed by the material and the film of mutually different mechanical characteristics as in the above arrangement of the thin film as the film, superior anti-corrosion property can be applied on the spring, slide resistance thereof can be reduced and energy accumulative therein can be increased by utilizing the superior mechanical characteristics inherent in the material and the film.

Incidentally, when the material is an stainless steel alloy including chromium, nitrogen to be strongly bonded with chromium may preferably be used as the diffusion substance.

The material may preferably be formed of a metal capable of thermomigration treatment.

By using such metal material, since the mechanical characteristics and shape can be easily preserved even when the metal is heated to a high temperature as compared to the other material such as synthetic resin, the process temperature can be increased in diffusion processing of the material, so that the diffusion speed of the diffusion substance can be accelerated to reduce time required for the diffusion treatment.

The diffusion layer may preferably be formed on the material by a diffusion treatment which supplies a gas including a molecule containing element of the diffusion substance into a high-vacuum furnace and the diffusion substance is diffused from the surface of the material to the inside.

Accordingly, since the hard diffusion layer is formed by mixing diffusion substance into the material, fragile layer is not formed on the border of the diffusion layer and the material, so that damage and peeling of the diffusion layer is not caused even after repetition of the elastic deformation, thereby obtaining a spring of superior durability.

A second aspect of the present invention is a driving mechanism using a spring formed as described above.

According to the second aspect, since the energy capable of being accumulated in the spring increases, continuous driving time can be lengthened as compared to general driving mechanism of the same size.

Further, by selecting the composition of the material and the film in accordance with the usage of the driving mechanism, the performance of the driving mechanism can be improved.

For instance, when a composition of the film has superior anti-corrosion properties, the anti-corrosion properties of the driving mechanism can be improved. Further, when a composition of the film has superior self-lubricity, even when the drive force generated by the spring is the same, the drive force capable of extracting from the driving mechanism becomes stronger than the driving mechanism using an ordinary spring.

A third aspect of the present invention is a device using the above-described spring.

According to the third aspect of the present invention, since the energy accumulated in the spring increases as in the second aspect of the

present invention, continuous drive time can be lengthened.

On the other hand, when long drive time is not required, the size of the spring can be reduced, so that the driving mechanism using the spring and, as a result, the size of the device can be reduced.

A fourth aspect of the present invention is a power source of electronic control mechanical timepiece or a simple mechanical timepiece using the above-described spring.

Specifically, the fourth aspect of the present invention is an electronic control timepiece, comprising: a mechanical energy accumulator for accumulating a mechanical energy; a power generator driven by the mechanical energy accumulator; a gear train for mutually connecting the mechanical energy accumulator and the power generator; an indicator connected to the gear train; and a rotation controller for controlling rotary speed of the power generator, or a timepiece comprising a mechanical energy accumulator and being driven by the mechanical energy accumulator, in which the mechanical energy accumulator uses a spring where at least a part of the surface of a material thereof has a film having composition and mechanical characteristics different from the material.

According to the fourth aspect of the present invention, since the energy capable of being accumulated in the spring increases and the energy per certain volume of the spring, i.e. the energy density, can be increased, the duration of the timepiece can be lengthened by the spring of the first aspect of the present invention when the spring of the same size is used. Further, since the size of the spring is reduced when the same duration is to be achieved, the size and weight of the timepiece can be reduced.

Brief Description of Drawings

Fig. 1 is a plan view showing a primary portion of a first embodiment of the present invention;

Fig. 2 is a cross section taken along II-II line in Fig. 1;

Fig. 3 is a cross section taken along III-III line in Fig. 1;

Fig. 4 is a cross section showing a barrel gear of the first embodiment of the present invention;

Fig. 5 is a block diagram showing a rotation control circuit of a power generator of the first embodiment;

Fig. 6 is a plan view showing a second embodiment of the present invention;

Fig. 7 is a cross section showing a primary portion of the second embodiment; and

Fig. 8 is a cross section showing a primary portion of a third embodiment of the present invention.

Best mode for Carrying out the Invention

An embodiment of the present invention will be described below with reference to attached drawings.

[First Embodiment]

Figs. 1 to 3 shows an electric-controlled mechanical timepiece according to first embodiment of the present invention. Fig. 1 is a cross section of a primary portion of the first embodiment, Fig. 2 is a cross section taken along II-II line in Fig. 1 and Fig. 3 is another cross section taken along III-III line in Fig. 1.

The electric-controlled mechanical timepiece is a device according to the present invention, where a mainspring 1A accommodated inside a barrel gear 1 is a driving mechanism to drive a power generator 20 by the

mainspring 1A and regulates the drive speed of the power generator 20 at a constant level to rotate the indicators 13, 14 and 17 engaged to the power generator 20 at a constant speed.

In the drawing, the barrel gear 1 is provided with a barrel 1B, a barrel arbor 1C and a barrel case 1D as well as the mainspring 1A.

The barrel arbor is supported by a base plate 2 and a gear train holder 3 and is fixed by a square-hole screw 5 to be integrally rotated with a ratchet wheel 4.

The ratchet wheel is meshed with a recoil click 6 which allows clockwise rotation without allowing counterclockwise rotation. Incidentally, since the mechanism for rotating the ratchet wheel 4 clockwise to wind up the mainspring 1A is the same as a self-winding or a hand-winding mechanical timepiece, description thereof is omitted.

The rotary drive force of the mainspring 1A is transmitted to the power generator 20 through a speed-up gear train composed of gears 7 to 11.

Specifically, the revolution number is multiplied by seven from the barrel 1B to a second wheel 7, the revolution number is multiplied by six point four from the second wheel 7 to a third wheel 8, the revolution number is multiplied by nine point three seven five from the third wheel 8 to a sweep second wheel 9, the revolution number is multiplied by three from the sweep second wheel 9 to the fifth wheel 10, the revolution number is multiplied by ten from the fifth wheel 10 to a sixth wheel 11, and the revolution number is multiplied by ten from the sixth wheel 11 to a rotor 12. Accordingly, the rotary drive force of the barrel 1B is transmitted to the rotor 12 multiplied by one hundred twenty six thousands.

The gears 7 to 11 constitute a mechanical energy transferring device for transferring the mechanical energy of the mainspring 1A as a mechanical

energy source to the power generator 20.

The second wheel 7 has a cannon-pinion 7A and a minute hand 13 fixed to the cannon-pinion 7A. A second hand 14 is fixed to the sweep second wheel 9. An hour hand 17 is fixed to an hour wheel 7B.

The rotary speed of the barrel 1B is regulated so that the second wheel 7 rotates once per hour and sweep second wheel 9 rotates once per minute, thereby setting the rotary speed of the rotor 12 at eight rotations per second. The rotary speed of the barrel 1B is one-seventh per hour. The hands 13, 14 and 17 constitute a time indicator for indicating time.

The mainspring 1A as a mechanical energy source has a band-shaped entire configuration and is wound in helical shape as shown in Fig. 4. Fig. 4(A) is a flat cross section horizontally cutting the barrel gear 1 and Fig. 4(B) is a vertical cross section vertically cutting the barrel gear 1.

An engage portion 1E thicker than the other portion is provided on an outer end of the mainspring 1A and is fixed to a recess 1F provided on an inner side of the barrel gear 1. By fixing the engage portion 1E to the recess 1F, the clockwise rotary drive force generated by the wound mainspring 1A is received by the barrel gear 1.

On the other hand, an engage hole 1G penetrating the front and back of the mainspring 1A is provided on an inner end of the mainspring 1A and is engaged to a projection 1H provided on a side of a barrel arbor 1C. The engagement of the engage hole 1G with the projection 1H enables the clockwise rotary drive force of the barrel arbor 1C to be received by the wound-back mainspring 1A.

Accordingly, the mainspring 1A is wound up by the clockwise rotary drive force applied to the ratchet wheel 4.

The mainspring 1A is formed by processing a material having

superior toughness and durability composed of alloy including chromium, cobalt and nickel in a band-shape. Incidentally, main components and content ratio thereof (weight percent) forming the material of the mainspring 1A are as follows.

Co: 30 to 45%, Ni: 10 to 20%, Cr: 8-15%, W: 3 to 5%,
Mo: 3 to 12 %, C: less than 0.03%, Ti: 0.1 to 2%, Mn: 0.1 to 2%
Si: 0.1 to 2%, Fe: the rest.

Films having different mechanical characters are coated on both sides of the mainspring 1A. Incidentally, tradename SPRON (manufactured by SEIKO CORPORATION) may be used as an alloy for forming the mainspring 1A.

The film is a thin film composed of carbon-amorphous rigid diamond-like carbon (referred to "DLC" hereinafter) harder than the material. The film is formed on the surface of the material by high-vacuum arc discharge vapor evaporation using solid carbon. The vapor evaporation by the high-vacuum arc discharge is a physical vapor evaporation capable of depositing vapor at a film-forming temperature around room temperature, e.g. twenty to sixty degrees Celsius.

The film has superior anti-corrosion properties without being dissolved into acid or alkali, and has smooth surface having friction coefficient of approximately 0.1. The film gives the surface of the mainspring 1A a superior anti-corrosion property and a great self-lubricity.

The film of DLC harder than the alloy-made material is provided to secure sufficiently great Young's modulus. Further, the film is made thinner than usual as long as sufficient toughness can be secured. Accordingly, the thickness of the spring 1A is smaller than an ordinary mainspring capable of generating the same torque.

Back to Figs. 1 to 3, the power generator 20 has the rotor 12, a stator 15 and a coil block 16. The rotor 12 has a rotor magnet 12A, a rotor pinion 12B and an inertial disk 12C. The inertial disk 12C is for relaxing drive torque fluctuation from the barrel 1B to lessen frequency fluctuation of the rotor 12. The stator 15 has a forty-thousand-turned stator coil 15B wound around a stator body 15A.

The coil block 16 has a one-hundred-ten-thousand turned coil 16B wound around a magnetic core 16A. The stator body 15A and the magnetic core 16A are composed of a magnetic substance such as PC Permalloy. The stator coil 15B and the coil 16B are serially connected to add the mutual output voltages.

The rotary speed of the power generator 20 is regulated to a predetermined speed by a rotation control circuit 23 described below. Incidentally, though the rotary speed of the power generator 20 is set at a single value in a normal timepiece, the rotary speed is switchable to a plurality of values in a timepiece such as a chronograph.

Fig. 5 shows a circuit arrangement including the rotation control circuit 23 in the first embodiment.

The power generator 20 is an alternating-current generator for generating an induced electromotive force by the rotary drive force of the mainspring 1A. The alternating output from the power generator 20 is voltage-raised and converted to a direct current by a rectifier 21 also for boosting, and is supplied to a power source 22 including a capacitor.

The rotation control circuit 23 has an oscillator for outputting a signal of predetermined frequency, a frequency divider 25 for dividing frequency of the signal outputted by the oscillator 24, a rotation detector 26 for detecting the rotation speed of the rotor 12 provided to the power

generator 20, and a brake controller 27 for controlling brake force applied to the rotor 12.

The oscillator 24 is an oscillating circuit using a quartz oscillator 24A capable of stably oscillating at a predetermined frequency (32.768kHz) scarcely being influenced by temperature change etc. The rotation of the rotor 12 is adjusted based on the oscillation of the oscillator 24.

The frequency divider 25 has a twelve-stage flip-flop for outputting a low frequency (8Hz) signal fs divided from the predetermined frequency (32.768kHz) signal outputted by the oscillator 24.

The rotation detector 26 outputs a rotation detection signal FG as a signal corresponding to a rotary speed to the rotor 12 of the power generator 20. The rotation detection signal FG is extracted by waveform-shaping of the output voltage of the power generator 20 through a band-pass filter in order to remove noise.

The brake controller 27 compares the signal fs as a rotary speed standard with a rotation detection signal FG and adjusts the electric current flowing in the stator coil 15B and the coil 16B of the power generator 20 in accordance with compared result, thus adjusting brake force of an electromagnetic brake applied to the rotor 12 of the power generator 20.

For instance, in order to minutely adjust the brake force of the electromagnetic brake applied to the rotor 12, an arrangement having a circuit serially connecting a switching element such as a transistor and a direct-current resistance can be used to conduct a high-speed on-off operation of the switching element to adjust on-time relative to off-time to minutely adjust the brake force of the electromagnetic brake.

When the frequency of the rotation detection signal FG relative to the signal fs is high by the brake controller 27, the on-time relative to the

off-time is lengthened to strengthen the brake force of the electromagnetic brake. On the other hand, when the frequency of the rotation detection signal FG is low relative to the signal fs, the brake controller 27 shorten the on-time relative to the off-time to weaken brake force of the electromagnetic brake to indicate accurate time by the pointers 13, 14 and 17.

According to the above first embodiment, following advantages can be obtained.

Since the mainspring 1A is formed by components having different mechanical characteristics such as an alloy-made material and DLC film, the toughness can be secured by the material and sufficient Young's modulus can be secured by the rigid film, so that proportional limit of the mainspring 1A can be increased to increase energy amount accumulated in the mainspring 1A.

Since the DLC film having superior anti-corrosion properties and having smooth surface and low friction coefficient is used to cover the material, great anti-corrosive properties can be applied to the mainspring 1A and, since slide resistance thereof can be reduced, loss of friction can be reduced in extracting the rotary drive force from the mainspring 1A to obtain greater torque.

Accordingly, since the energy which can be accumulated in the mainspring 1A as a driving mechanism can be increased, the time for continuously driving the electronic control mechanical timepiece becomes longer than a general mainspring of the same size, thereby lengthening duration of the drive of the electronic control mechanical timepiece.

Further, since the DLC film harder than the alloy-made material is used to secure sufficient magnitude of Young's modulus by the film and the thickness of the material is reduced within a range capable of obtaining

sufficient toughness to reduce thickness of the mainspring 1A, effective winding number of the mainspring 1A from being completely unwound to being wound to the limit can be increased, thereby also increasing the energy which can be accumulated in the mainspring 1A.

Since the mainspring 1A is a spring formed in a band-shape and in helical configuration, energy can be suitably accumulated mechanically, so that energy accumulation can be increased as compared to the other form of spring of the same size, thereby increasing energy density.

Further, since the film is formed by vapor evaporation by a high-vacuum arc discharge using a solid carbon, even when the film is formed on the surface of the material after thermal treatment of the material such as hardening and tempering, because the vapor evaporation by the high-vacuum arc discharge is a physical vapor depositing capable of depositing vapor at a film-forming temperature around the room temperature such as twenty to sixty degrees Celsius, the material is not thermally influenced, thereby preserving characteristics of the material after forming the film.

[Second Embodiment]

Figs. 6 and 7 shows the second embodiment of the present invention. The second embodiment uses a mainspring 1A of the spring of the above-mentioned first embodiment as a plate spring 33 for biasing a push button 32 as a key 31 of a keyboard 30.

In Fig. 6, the keyboard 30 is a manual inputting device for a personal computer and includes a plurality of keys 31.

Respective keys 31 have, as shown in Fig. 7(A), a relatively rigid reinforcing plate 34 without being bent by a pressing force applied to the push button 32 in operation and a membrane contact point portion 35

disposed on the reinforcing plate 34.

The membrane contact point portion 35 has a pair of electrode sheets 36 having flexibility and electrode pattern formed on the inner surface thereof, and a spacer plate 38 provided between the electrode sheets 36 and having holes 37 corresponding to the position of the push buttons 32. A pair of contact points 39 opposing inside the holes 37 of the spacer plate 38 are provided on the respective sheets 36.

A plate spring sheet 33A integrally formed with the plate spring 33 is provided on an upper side of the membrane contact point portion 35. The plate spring sheet 33A has a relatively rigid flat-plate material. The composition of the material of the plate spring sheet 33A may be a synthetic resin having relatively great elasticity such as polypropylene, polyamide, polyacetal and polytetrafluoroethylene, or metal.

A surface of the plate spring sheet 33A on the side of the membrane contact point portion 35 has the DLC film formed by vapor evaporation of high-vacuum arc discharge. Even when the material is formed of a composition unable to secure sufficient bonding strength of the film to the material, since the film is formed on the surface 33B applied with the compressive force, the film is not peeled off from the material when the plate spring 33 is deformed.

The plate spring 33 is formed by cutting and raising a part of the plate spring sheet 33A in a direction opposite to the membrane contact portions 35. The material of the plate spring 33 is coated with the DLC film on the surface 33B onto which the compressive force is applied during elastic deformation.

A pressing portion 33C is formed by cutting and raising a part of the plate spring 33 to the side of the membrane contact point portion 35. The

plate springs 33 and the pressing portion 33C are accommodated in the box-shaped housing 40 formed on the upper side of the plate spring sheet 33A.

The push button 32 is a box-shaped member slightly greater than the housing 40 covering the housing 40 and provided to the keyboard 30 in a vertically movable manner. A projection 32A extending toward the plate spring 33 is provided inside the push button 32.

Accordingly, when the push button 32 is pressed against the biasing force of the plate spring 33, the projection 32A presses the pressing portion 33C toward the membrane contact point portion 35 side through the plate spring 33 as shown in Fig. 7(B) to bring the pair of contact points 39 inside the membrane contact point portion 35 into mutual contact.

According to the second embodiment, following advantage can be obtained.

Since the DLC film is formed on the surface 33B on the side of the membrane contact point portion 35 of the plate spring sheet 33A by high-vacuum arc discharge vapor evaporation so that only the compressive force is applied to the film by deforming the plate spring 33 and tension is not applied, even when the material is formed of a composition unable to secure sufficient bonding strength of the film to the component, the film does not peel off from the material, thus improving durability of the plate spring 33.

[Third Embodiment]

Fig. 8 shows a third embodiment of the present invention. The third embodiment uses the plate spring 33 of the second embodiment as a coil spring 41.

In Fig. 8, a key 42 brings the contact points 39 inside the membrane

contact point portion 35 provided on the reinforcing plate 34 into mutual contact by the pressing force applied to the push button 43.

The upper portion of the membrane contact point portion 35 is covered with a flat cover 44. A hole 44A is formed on the cover 44 corresponding to the position of the contact points 39 provided on the membrane contact point portion 35. A rubber spring 45 having a material of synthetic resin elastomer is fitted to the hole 44A.

The rubber spring 45 has the DLC film formed on the entire surface of the synthetic resin elastomer material. The film is formed by vapor evaporation by the high-vacuum arc discharge. The film gives the rubber spring 45 a superior anti-corrosion properties preventing dissolution to acid, alkali and organic solvent. Further, even when the synthetic resin elastomer as the material thereof is soft and sufficient elasticity cannot be obtained solely by the material, the rubber spring 45 has sufficient elasticity by the DLC film. A cylindrical projection 45A is formed on the rubber spring 45 for pressing the membrane contact point portion 35.

The reinforcing plate 34, the membrane contact point portion 35, the cover 44 and the rubber spring 45 are provided in a housing 46 forming a chassis of the keyboard 30.

A hole 47 formed to a position corresponding to the contact point 39 provided on the membrane contact point portion 35, a cylindrical guide 48 extending upward surrounding the hole 47, and a retaining portion 49 having L-shaped cross section disposed outside the guide 48 are provided to the housing 46.

An engaging projection 50 having a claw 50A engaged to the retaining portion 49 of the housing 46, a cylindrical slide guide 51 having outer circumference in contact with the guide 48 for guiding the vertical

movement of the push button 43, and a projection 52 for engaging the coil spring 41 for preventing horizontal movement thereof are provided on the backside of the push button 43.

A bottomed-cylindrical slide member 53 is slidably provided inside the cylindrical slide guide 51.

The slide member 53 has a projection 54 on the bottom thereof for engaging the coil spring 41 to prevent horizontal movement. The coil spring 41 is interposed between the slide member 53 and the push button 43, and the rubber spring 45 is interposed between the slide member 53 and the membrane contact point portion 35.

Accordingly, when the push button 43 is pressed against the biasing force of the coil spring 41 and the rubber spring 45, the projection 45A of the rubber spring 45 presses the membrane contact point portion 35 to bring the pair of contact points 39 inside the membrane contact point portion 35 into contact with each other.

The coil spring 41 has the DLC film formed on the entire surface of a linearly shaped steel-made material. The film is formed by vapor evaporation by high-vacuum arc discharge. The coil spring 41 has superior anti-corrosive properties without being dissolved into acid or alkali on account of the film and has decreased friction coefficient on the surface thereof.

According to the third embodiment, following advantages can be obtained.

Since the rubber spring 45 having the DLC film formed on the entire surface of a synthetic resin elastomer material is used, the rubber spring 45 can have superior anti-corrosive properties without being dissolved into acid, alkali and organic solvent. Further, when the synthetic resin elastomer is

too soft to have sufficient elasticity solely by the material, sufficient elasticity can be given to the rubber spring 45 by the DLC film. Accordingly, high-performance rubber spring 45 can be efficiently manufactured by forming the synthetic resin elastomer by injection molding etc.

Further, since the coil spring 41 has the DLC film formed on the entire surface of the linearly shaped steel-made material, superior anti-corrosive properties can be given to the steel-made material, thereby improving durability of the keyboard 30. Further, since the friction coefficient on the surface of the coil spring 41 can be reduced, smooth operation is possible, thereby improving operability thereof.

[Fourth Embodiment]

Fourth embodiment of the present invention has a film formed of diffusion layer where a diffusion substance is diffused from the surface of the material by a vacuum diffusion method instead of the thin film formed by the physical vapor deposition in the first embodiment. The arrangement of the fourth embodiment is the same as the above-described first embodiment except for the film formed on the mainspring 1A, and the film composed of diffusion layer will be described below and the description for the other component will be omitted.

The film is a diffusion layer where nitrogen strongly bonded with chromium contained in the alloy as the material of the mainspring 1A is used as the diffusion substance, which is formed by vacuum gas nitriding treatment for diffusing the nitrogen into the inside of a material inside a high-vacuum furnace.

The vacuum gas nitriding treatment may be, for instance, "Kanuc treatment" and "new Kanuc treatment" of Kanuc CORPORATION.

The outline of "Kanuc treatment" is: Supplying a nitriding accelerating gas mainly containing NH_3 having nitrogen atom into the vacuum furnace with high-vacuum and the material being disposed therein; Heating the material (heating temperature : 480 to 550°C, heating time: three to five hours); and diffusing the nitrogen inside the material to form the diffusion layer of the nitrogen.

The "new Kanuc treatment" is for further strengthening the diffusion layer formed in the "Kanuc treatment", where heat energy is applied again on the diffusion layer of the material treated with "Kanuc treatment" to form first diffusion layer having higher density of nitrogen atom than the diffusion layer by the "Kanuc treatment" on the surface thereof and the second diffusion layer having lower density of the nitrogen atom than the first diffusion layer on the backside of the first diffusion layer, thereby forming double structured diffusion layer.

According to the fourth embodiment, the same functions and advantages as the first embodiment can be obtained. Further, since rigid diffusion layer is formed by diffusing nitrogen inside the material, fragile layer is not formed on the border between the diffusion layer and the material, so that damage or peeling of the diffusion layer can be prevented after repeating elastic deformation, thereby obtaining a mainspring 1A having superior durability.

Next, an effect of the present invention will be described below with reference to specific experiments.

[Experiment]

The present experiment is for exemplifying that the mainspring 1A provided to the barrel gear as the driving mechanism in the above-described first and fourth embodiment can accumulate more energy than a

conventional mainspring.

In the experiments, the experiment 1 used a mainspring 1A having DLC thin layer formed on the surface of SPRON-made material and the experiment 2 used a mainspring 1A having nitrogen diffusion layer formed by "Kanuc treatment" on the surface of SPRON-made material.

In the experiment 1, the thickness of the mainspring 1A was reduced as long as a predetermined torque could be obtained, where the mainspring 1A was accommodated in a barrel gear 1 having inner diameter of 11.1mm, a diameter of barrel arbor of 2.8mm, and thickness of the peripheral sidewall of the barrel of 1.45mm. The number capable of winding the mainspring from unwound condition to completely wound-up condition was measured.

In the experiment 2, the "Kanuc treatment" was used in order to form the diffusion layer on the material, and production of the mainspring 1A having the same performance as the experiment 1 was tried and, as a result, the mainspring 1A having the same performance as the experiment 1 could be obtained.

Dimensions of respective portions of the mainspring 1A, Young's modulus, maximum torque T and winding number N according to the experiments 1 and 2 are shown in Table 1.

(Table 1)

	Thickness of mainspring (mm)	Width of mainspring (mm)	Length of mainspring (mm)	Young's modulus (Pa)	Maximum torque T (N/m)	Winding number N
Experiment 1	0.12	1.4	408	3.0×10^{10}	1.3×10^{-2}	8.4
Experiment 2	0.12	1.4	408	3.0×10^{10}	1.3×10^{-2}	8.4
Comparison	0.13	1.4	370	2.3×10^{10}	1.3×10^{-2}	7.6

[Comparison]

The comparison is an example of conventional mainspring for comparing with the mainspring 1A of the experiments.

In the comparison, simple SPRON-made mainspring capable of obtaining maximum torque as the mainspring 1A was used. The mainspring was accommodated in the same barrel gear 1 and the number capable of winding the mainspring from unwound condition to completely wound-up condition was measured.

The dimensions of respective portions of the mainspring, Young's modulus, maximum torque T and winding number N are shown in Table 1.

[Comparing Experiments and Comparison]

When the experiments 1 and 2 and the comparison were compared, the experiments 1 and 2 allowed more winding number of the mainsprings, thus extending duration for driving the electronic control mechanical timepiece, so that energy amount could be increased by 11% in the experiments as compared to the comparison.

When the mainspring of the experiments 1 and 2 is applied to a simple mechanical timepiece, the energy accumulation capable of being accumulated in the mechanical timepiece can be increased by 11%, thus extending duration for driving the mechanical timepiece.

Incidentally, the present invention is not limited to the respective embodiments and experiments, but includes improvements and modifications as long as an object of the present invention can be achieved.

For instance, the mainspring is not limited to those having rigid film on both sides thereof, but a mainspring having the rigid film solely on single center (inner) side of helically wound spring and having no rigid film on the other peripheral (outer) side may be used.

Accordingly, though a compression stress is constantly applied to the

rigid film, tensile stress is not applied thereto, so that the rigid film is not damaged even when a great stress is applied in winding the mainspring since the rigid film is highly durable against the compression stress. Further, since the rigid film is formed on one side of the mainspring, the thickness of the rigid film can be restrained to the minimum to reduce the thickness of the entire mainspring and winding number can be increased thereby, so that duration of driving the mainspring can be lengthened.

Further, when the rigid film is formed on both sides of the mainspring, one of the rigid films formed on one side may have greater thickness than the other rigid film provided to the other side. For instance, the rigid film formed on the surface where the compression force is applied may be made thick and the rigid film formed on the surface where the tensile stress is applied may be made thin. Alternatively, the type of the rigid film formed on both sides may differ. In other words, a rigid film having characteristic different from the rigid film formed on one side may be formed on the other side.

The material of the spring component is not restricted to the alloy described in the embodiments, steel and synthetic resin, but may be other alloys such as stainless steel, metal and non-metal. According to the present invention, even when the material of the spring component has not so superior characteristics, the performance of the spring can be improved by coating the film.

The thin film to be the film is not restricted to the DLC thin film, but may be thin film of polycrystal or single crystal diamond, ceramic thin film such as silicon nitride, silicon carbide, aluminum oxide, titanium carbide, titanium nitride, and cubic boron nitride, or metal thin film such as nickel-phosphorus plating.

The film forming method of the thin film is not limited to the vapor evaporation by the high-vacuum arc discharge, but may be physical film-forming method such as other vapor evaporation, sputtering and ion plating method, and chemical film-forming method such as heat CVD, plasma CVD and optical CVD. However, a method having film-forming temperature around room temperature may preferably be used.

The diffusion layer as the film is not limited to the diffusion layer of nitrogen, but may be a diffusion layer composed of other element such as carbon, beryllium, molybdenum, tungsten, vanadium, titanium and tantalum diffused into the material when the material is steel.

The diffusion layer as the film may be formed not only by gas diffusion treatment such as "Kanuc treatment" and "new Kanuc treatment" but by solid diffusion method where a solid diffusion agent and the material is put into a diffusion furnace and sealed therein or by liquid diffusion method where the material is soaked in liquid containing diffusion substance and is heated therein. However, since the material is not deformed by the "Kanuc treatment" and "new Kanuc treatment" as in the fourth embodiment even after the diffusion treatment, a spring suitable for a timepiece as a precision device can be manufactured.

The film formed on the material is not restricted to a single layer but may be a plurality of different type layers. Accordingly, if bonding strength to the material, anti-corrosion properties of spring and slide properties cannot be improved only by a single film, by providing a plurality type of films having different characteristics, the bonding strength can be improved by one film, and the anti-corrosion properties and slide properties can be improved by the remaining film, thus achieving high-performance spring.

For instance, a first composition having great rigidity and small

bonding strength to the material and a second composition which strongly adheres both to a first film and the material may be prepared, and a second film composed of the second composition may be directly formed on the material and a first film composed of the first composition may be formed on the second film, thereby improving bonding strength of the film.

Alternatively, a first composition having great rigidity and inferior anti-corrosion properties and self-lubricity and a second composition superior both in the anti-corrosion properties and self-lubricity may be prepared, and a first film composed of the first composition may be formed directly on the material and the second film composed of the second composition may be formed on the first film, thereby improving both of the anti-corrosion property and self-lubricity of the spring.

Further, the timepiece is not restricted only to the electronic control mechanical timepiece for controlling the rotary speed of the power generator but may be a normal mechanical timepiece for controlling rotary speed by a balance and an escape wheel. Further, the barrel may not only be single but more than one barrels may be provided.

Industrial Availability

The present invention relates to a spring used as a machine element, a driving mechanism, a device and a timepiece using the spring, which can, for instance, be suitably used for a helical spring for driving intake valve and exhaust valve of a gasoline engine, shock absorber around wheels of a vehicle, power source of toys, timepiece, music box etc.

Claims

1. A spring manufactured by processing an elastic material, at least a part of the surface of the material formed with a film having composition and mechanical characteristics different from the material.

2. The spring according to claim 1, wherein the film is harder than the material.

3. The spring according to claim 1 or 2, wherein a plurality of layers of the film are provided.

4. The spring according to any one of claims 1 to 3, wherein the material is processed in a band-shape and wound in helical shape so that the spring becomes a mainspring.

5. The spring according to any one of claims 1 to 4, wherein the film is formed on a surface to which a compressive force is applied when the material is elastically deformed.

6. The spring according to any one of claims 1 to 5, wherein the film is a thin film of a substance harder than the material coated on the surface of the material.

7. The spring according to claim 6, wherein the material is formed of a non-metal.

8. The spring according to claim 6 or 7, wherein the thin film is formed on the material by a physical vapor evaporation of which film-forming temperature is around a room temperature.

9. The spring according to any one of claims 1 to 5, wherein the film is a diffusion layer formed harder than the material by diffusing a diffusion substance strongly bonded with a composition constituting the material from the surface of the material to the inside.

10. The spring according to claim 9, wherein the material is formed of a metal capable of thermomigration treatment.

11. The spring according to claim 9 or 10, wherein the diffusion layer is formed on the material by a diffusion treatment which supplies a gas including a molecule containing element of the diffusion substance into a high-vacuum furnace and the diffusion substance is diffused from the surface of the material to the inside.

12. A driving mechanism using a spring according to any one of claims 1 to 11 as a power source.

13. A device using a spring according to any one of claims 1 to 11.

14. An electronic control timepiece, comprising:

a mechanical energy accumulator for accumulating a mechanical energy;

a power generator driven by the mechanical energy accumulator;

a gear train for mutually connecting the mechanical energy accumulator and the power generator;

an indicator connected to the gear train; and

a rotation controller for controlling rotary speed of the power generator,

wherein the spring according to any one of claims 1 to 11 is used as the mechanical energy accumulator.

15. A timepiece comprising a mechanical energy accumulator and being driven by the mechanical energy accumulator, wherein the spring according to any one of claims 1 to 11 is used as the mechanical energy accumulator.

FIG. 1

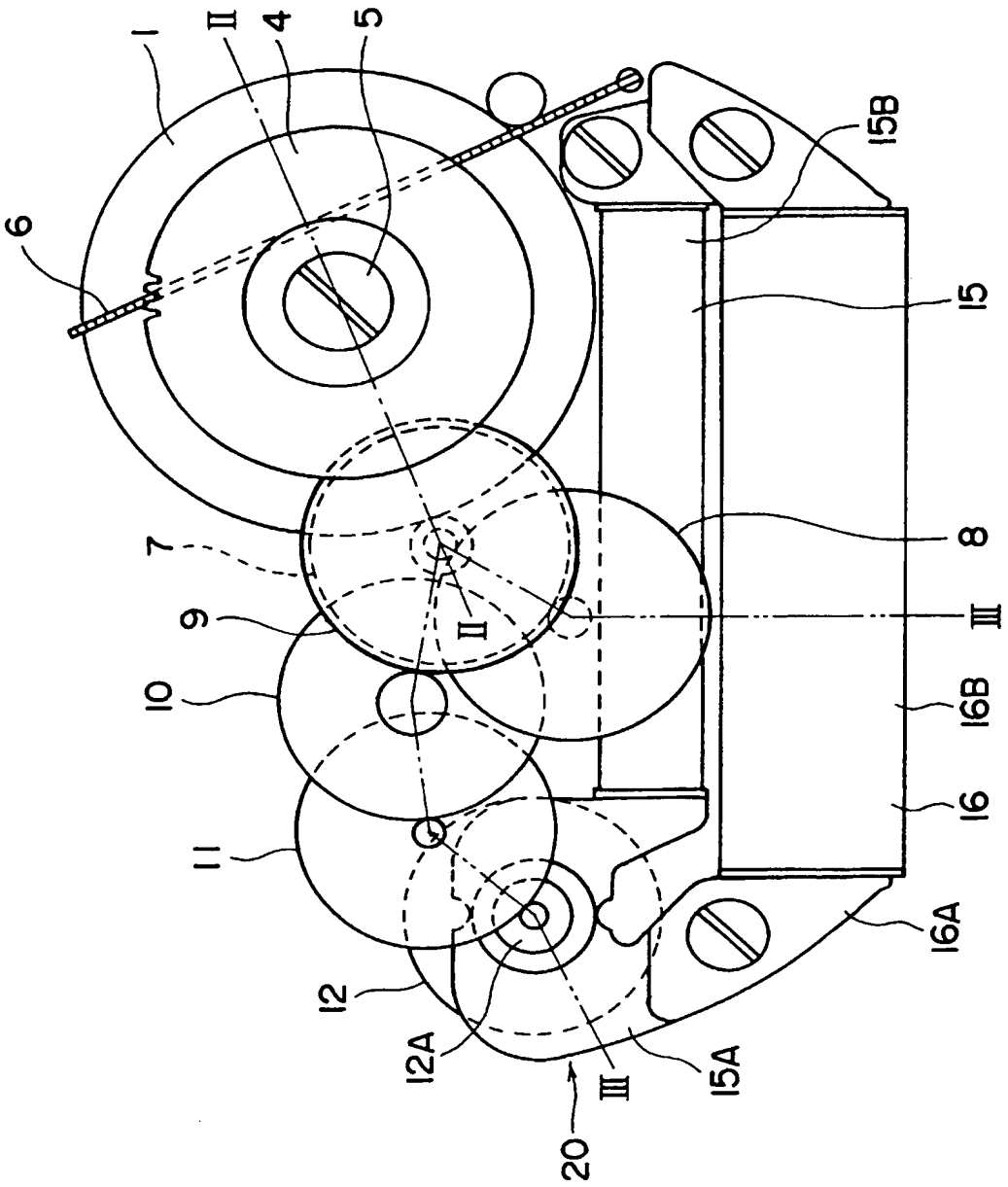


FIG.2

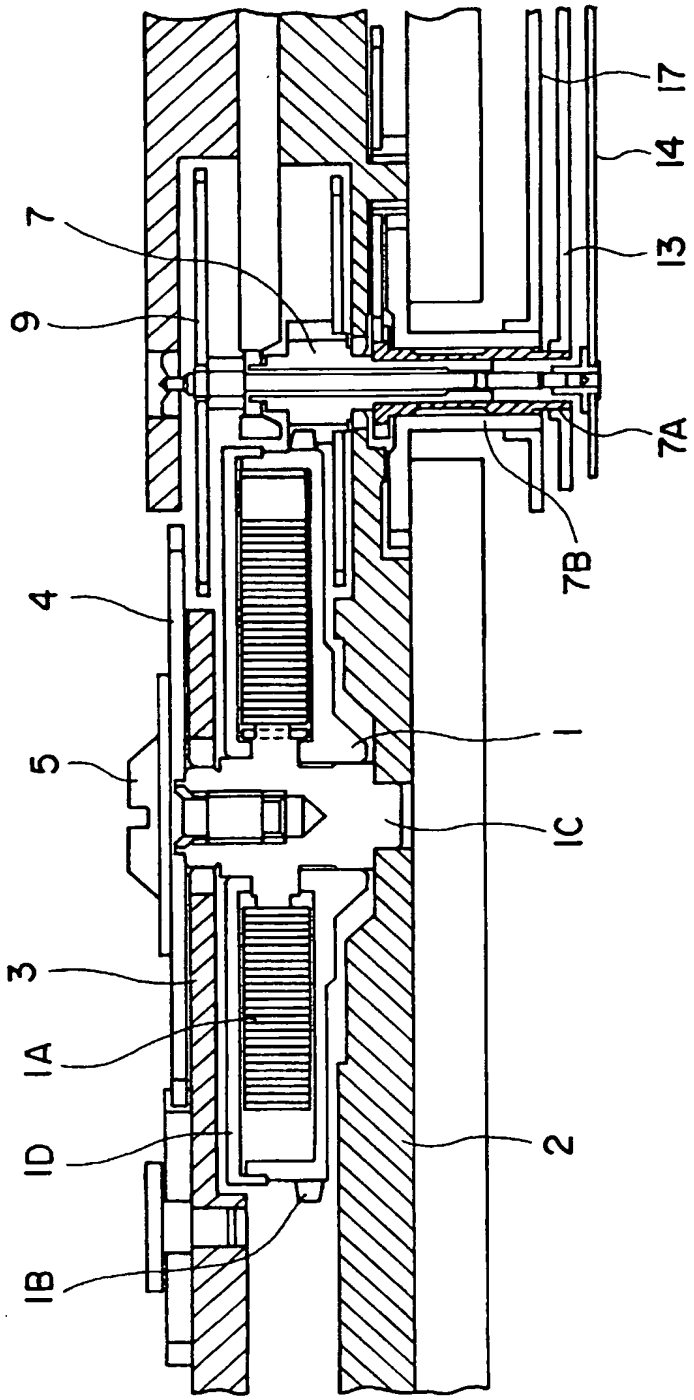
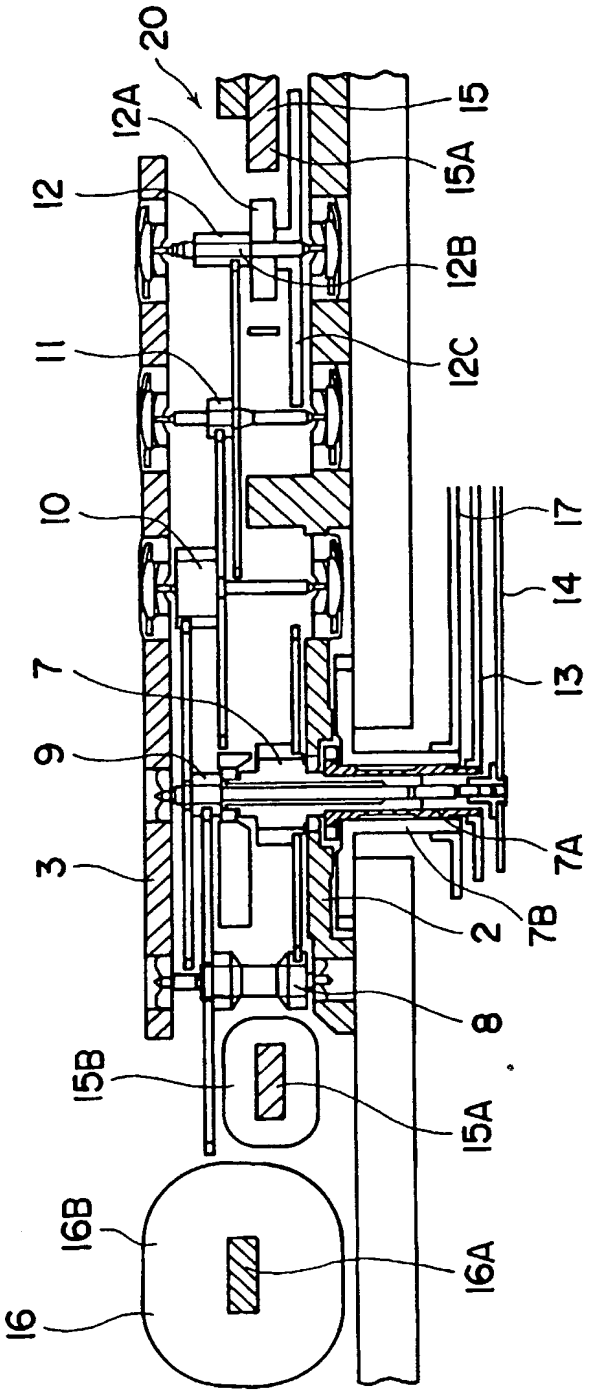


FIG.3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12
12B
12C
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FIG. 4

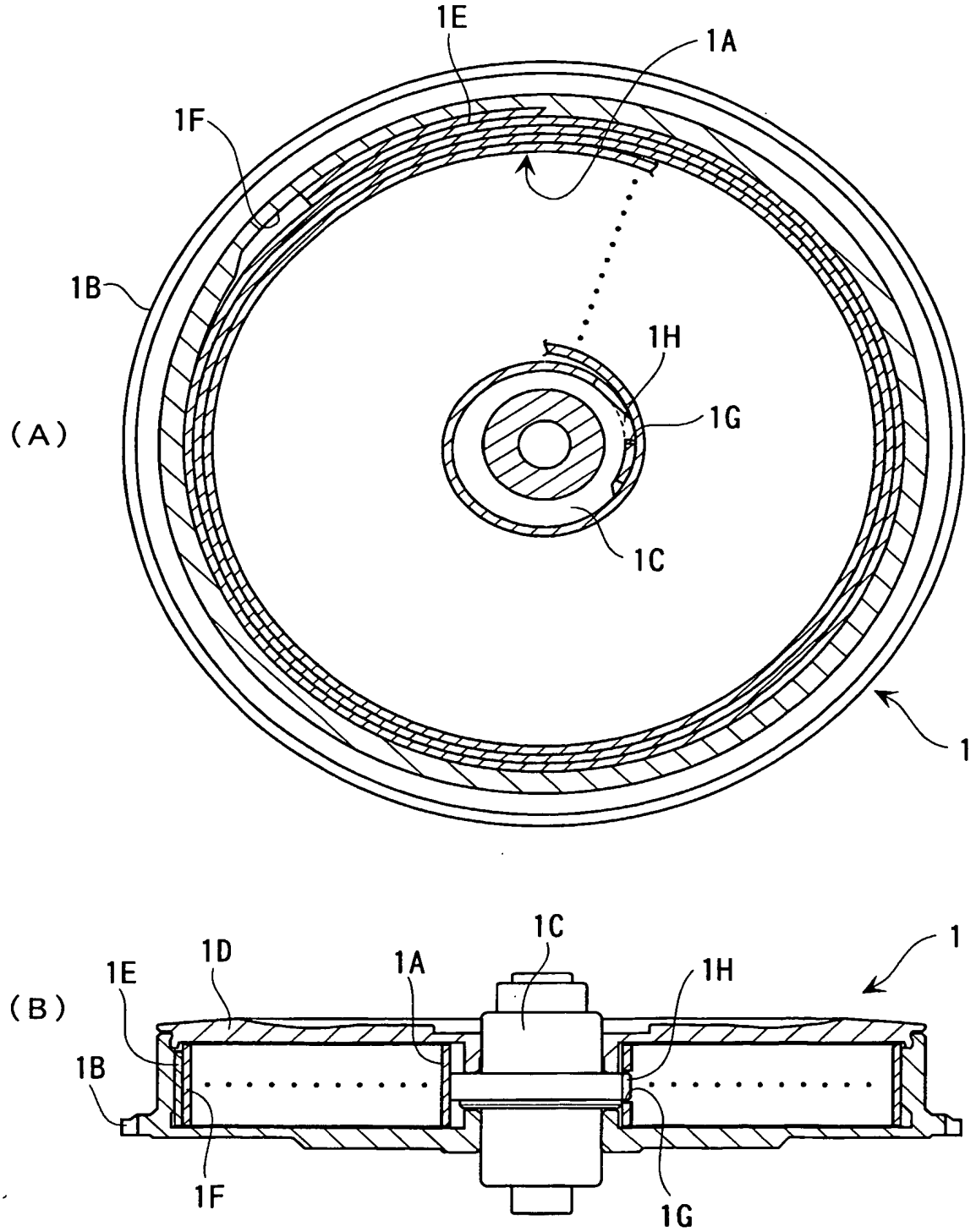
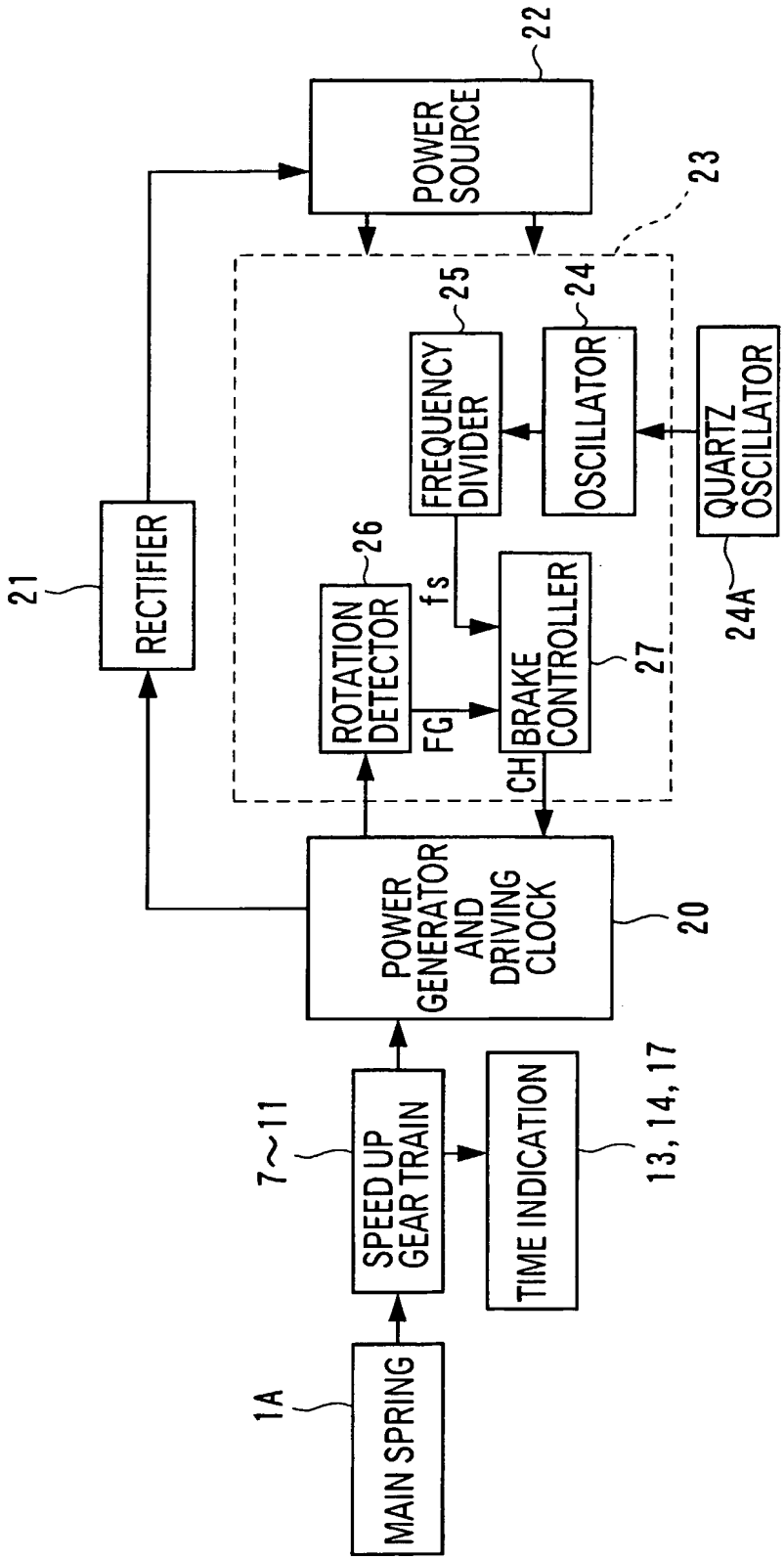


FIG.5


MAIN SPRING
1A
SPEED UP GEAR TRAIN
7~11
TIME INDICATION
13, 14, 17
POWER GENERATOR AND DRIVING CLOCK
20
RECTIFIER
21
POWER SOURCE
22
23
FREQUENCY DIVIDER
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BRAKE CONTROLLER
27
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FIG.6

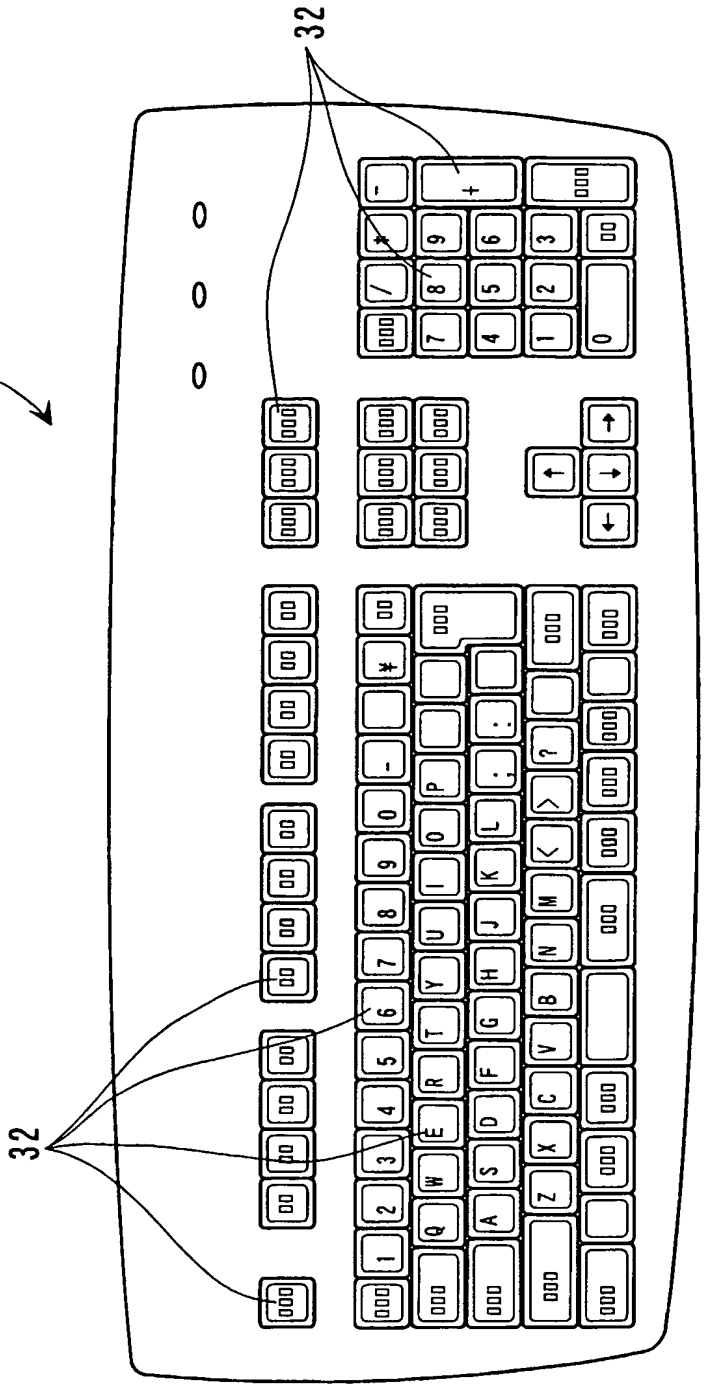

FIG. 7

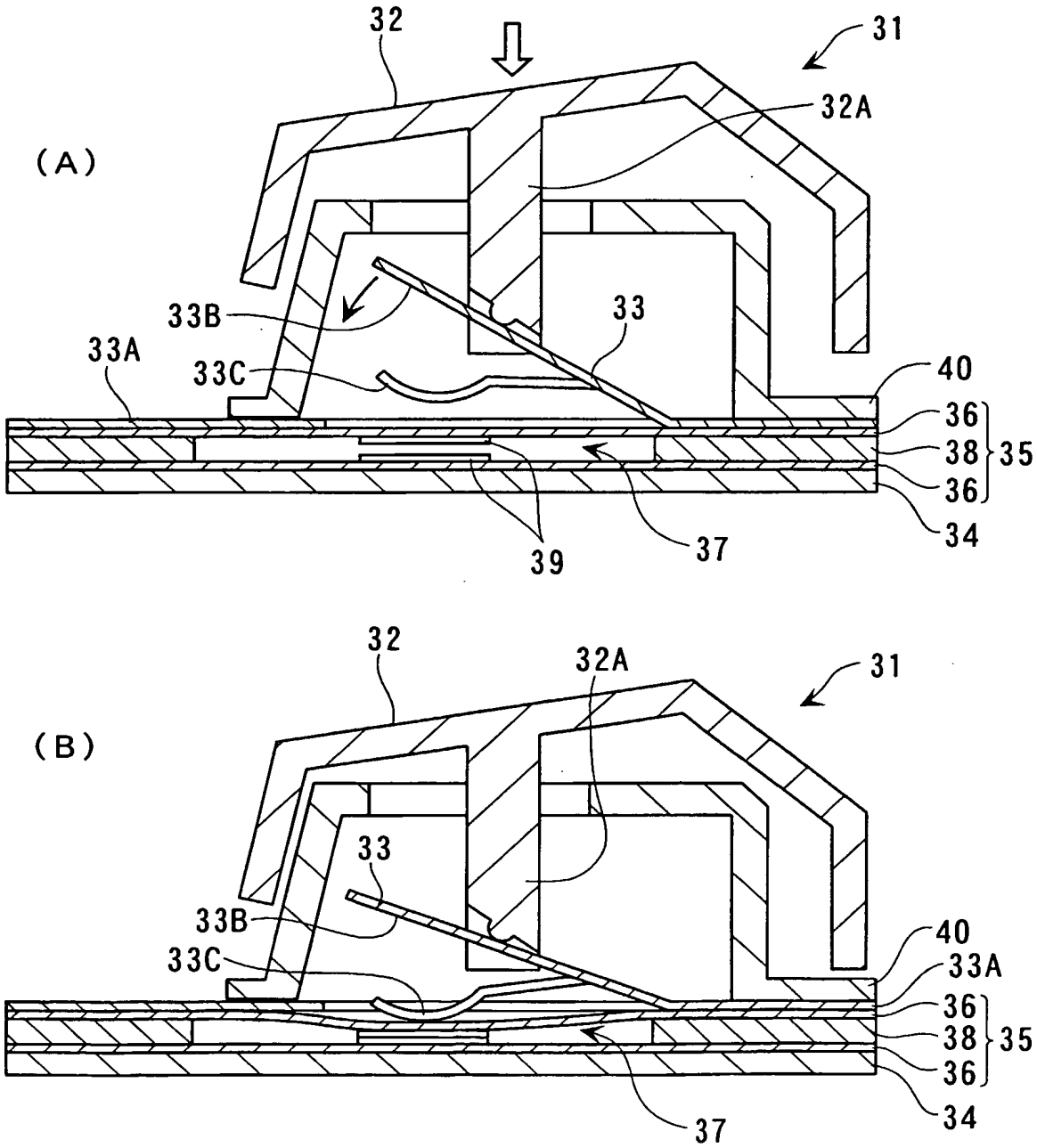
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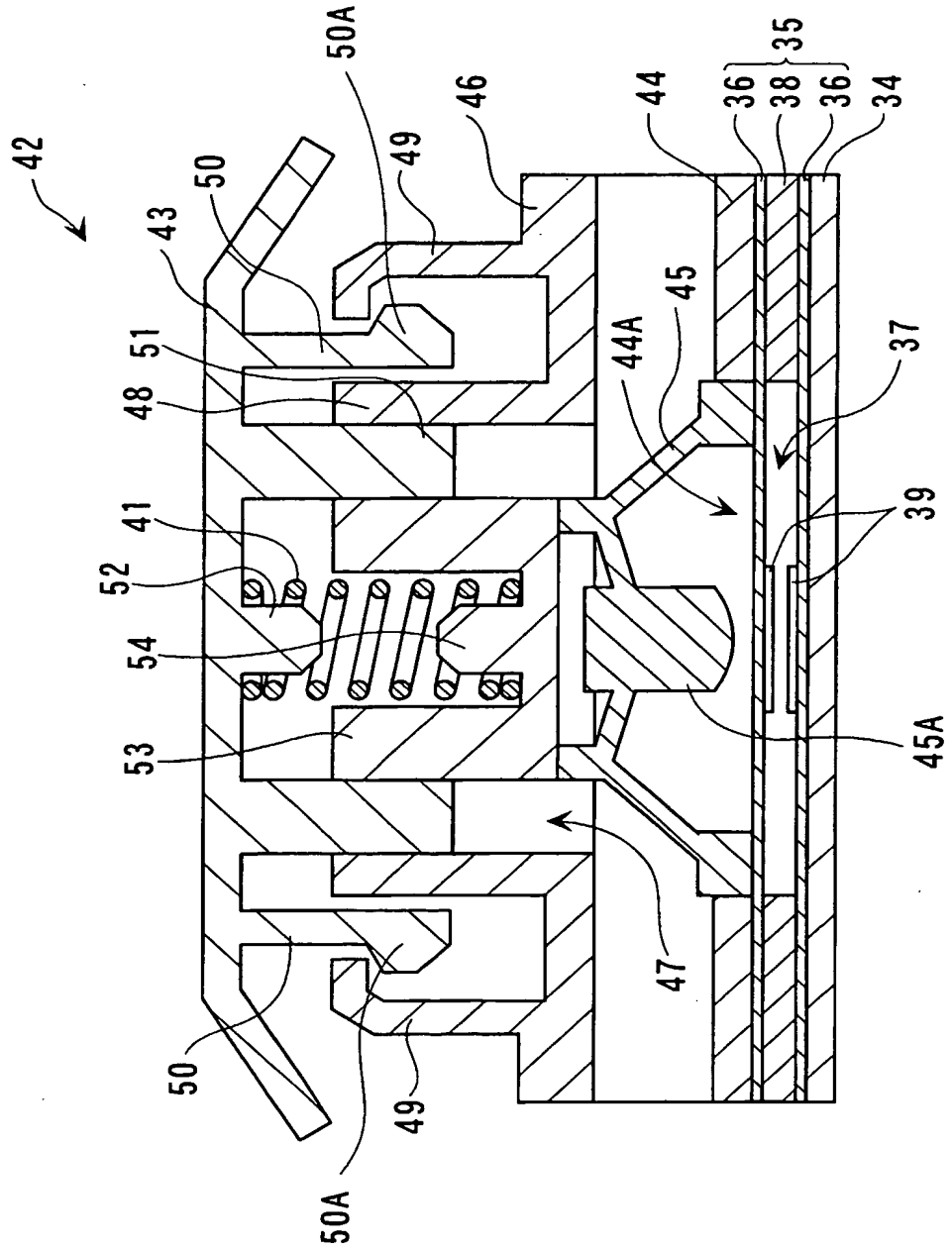
FIG.8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